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Design Of Open Drainage System Using The Study Of Rainfall In Urban Areas Study Area: LB Nagar, Hyderabad

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Abstract – Urban flooding was considered a concern of municipal and local governance only till the 1990s,but currently it draws the attention of disaster and environmental scientists. Urban floods have attained the status of disaster due to high vulnerability and risks. It leads to extreme fatalities and enormous economical losses in every country. Especially in developing countries like India, where population density is high and has enormous population growth during the last few decades due to high migration in urban areas and have a lot of issues about uncontrolled and inappropriate development .Flood is a phenomenon occurring from time to time in all rivers. An attempt has been made in this project to study the rainfall in urban areas & the effects area and solution of flash floods.

Keywords – Frequency, Extreme rainfall depth, Depth area duration, Probable maximum temperature, Rate of infiltration, Infiltration Capacity, initial infiltration capacity, limiting constant value of infiltration

I.INTRODUCTION

Hydrology is the science which deals with the occurrence, circulation and distribution of water upon, over and beneath the earth surface. It is the science concerned with the transportation water vapours through the air, the precipitation

Occurring on the ground as rainfall or snowfall of water over the ground surface and through the underground strata of the earth. Transpiration from the plants and various other allied processes occurring in nature. The basic knowledge of hydrology is essential for the irrigation engineer engaged in the development. Utilisation and management of water resources and in the construction of various multipurpose river valley projects. It helps him assessing the quantity of water available for irrigation, hydropower, municipal and industrial water supply, navigation and various other purposes. It is required for the estimation of the maximum discharge for the design of spillways, aqueducts, bridges and sewers. Hydrologic studies are also necessary for flood control, erosion control, pollution control, and various other related works. Hydrology is an inter-disciplinary science. It borrows heavily from other sciences such as meteorology, physics, chemistry, biology, geology, fluid mechanics, agriculture and statistics. It integrates all these sciences for its own interpretation. Engineering hydrology (or applied hydrology) is concerned with engineering application of hydrology. It deals with design and construction of engineering projects for the control, use and management of water. The irrigation engineer is mainly concerned with engineering application of hydrology. This deals with descriptive hydrology. It is divided into 5 parts Precipitation Infiltration, Evaporation, Transpiration and Evapotranspiration, Runoff.

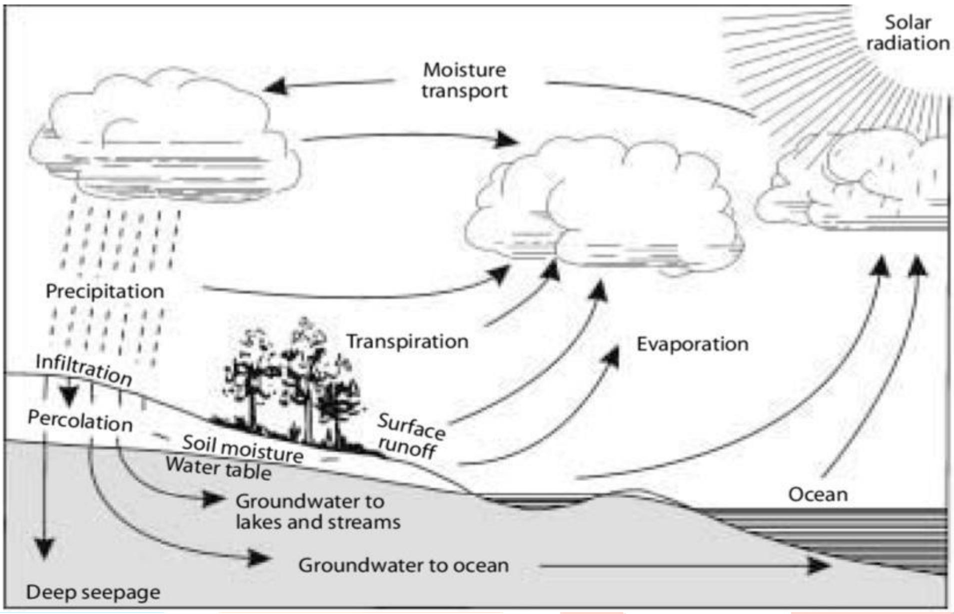


Fig 1.1 The Hydrological Cycle

1.1 ADVANTAGES OF OPEN DRAINAGE SYSTEM

Open drainage systems in urban areas offer several practical advantages, particularly in settings where resources, infrastructure, or rapid urbanization pose constraints. One of the most notable benefits is the relatively low cost of construction and maintenance compared to closed or underground drainage systems. These open channels can be built quickly and with minimal technical requirements, making them especially useful in fast-growing urban areas or informal settlements. Their open nature allows for easy visual inspection, which simplifies the identification of blockages, debris, or structural damage. This visibility not only facilitates routine cleaning and timely repairs but also promotes greater public awareness and engagement in maintaining cleanliness and functionality.

Furthermore, open drains provide natural ventilation, which helps in releasing gases and prevents pressure build up that might occur in closed systems. In regions prone to heavy rainfall or flooding, these systems can also act as overflow channels, efficiently directing excess surface runoff away from roads and residential areas. Their design flexibility allows for easy modifications or extensions, enabling urban planners to adapt drainage networks as cities expand. Despite their drawbacks, such as health and sanitation concerns, the advantages of open drainage systems make them a practical interim solution in many developing urban environments.

II. LITERATURE SURVEY

Paui Bimal Kanti and Rasid Harun (1993): Present paper stated that, temporal and spatial patterns of damage to rice crops in Bangladesh resulting from river flooding are analysed countrywide for the period 1962 to 1988 and at the district level from 1967 to 1988. Flood annually damaged approximately 4% of total rice production.

Kulkarani A.K., Mandal B.N. and Sangam R.B., Pune (1994): The paper studies of heavy rainfall 22 23 August. 1990 over Vidarbha region of Maharashtra. Present information is useful to the hydrologists for planning and design of water resources projects in the Vidarbha region of Maharashtra.

Mangat H.S., Patiala (1994): Present paper consist to the July 1993 floods of Punjab particularly Patiala city. The devastation associated with floods are directly related with their level and duration instead of the extent of area under floods, which are further associated with rainfall characteristics and manmade obstructions not only at local level but at regional scale.

Ram Satta. (1996): He studies Flood affected area of Badlapur Block and 12 villages of khutahan Block. The area located in the North-Western part of the district Jaunpur (U.P.). He explain nature of flood, flood hazard zone and types of flood plains of its study area. Deosthali Vrishali (1997): The present paper is an attempt to investigate the rain spells over Pune obtained from histograms with respect to duration; yield and their contribution to seasonal rainfall. The monsoon rainfall over Pune is broadly

characterized by 75% of the spells of less than one hour duration and 90% of the spells of less than 10 mm yield.

Pande Anita and Jalal D.S. (1997): They stated that geomorphologic aspects connected with the flash-flood, Slope condition, litho-structural setting including presence of major geologic structures like fault and thrust, drainage aspects etc. are studied in detail.

III. PROPOSED METHODOLOGY

The methodology shows the step-by-step procedure and their detailed explanation about b experimental process and observations are explained.

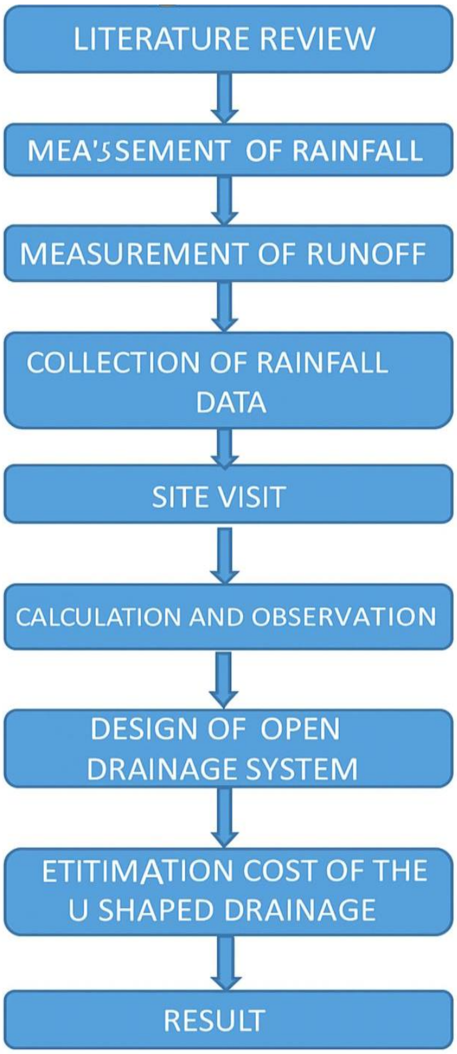


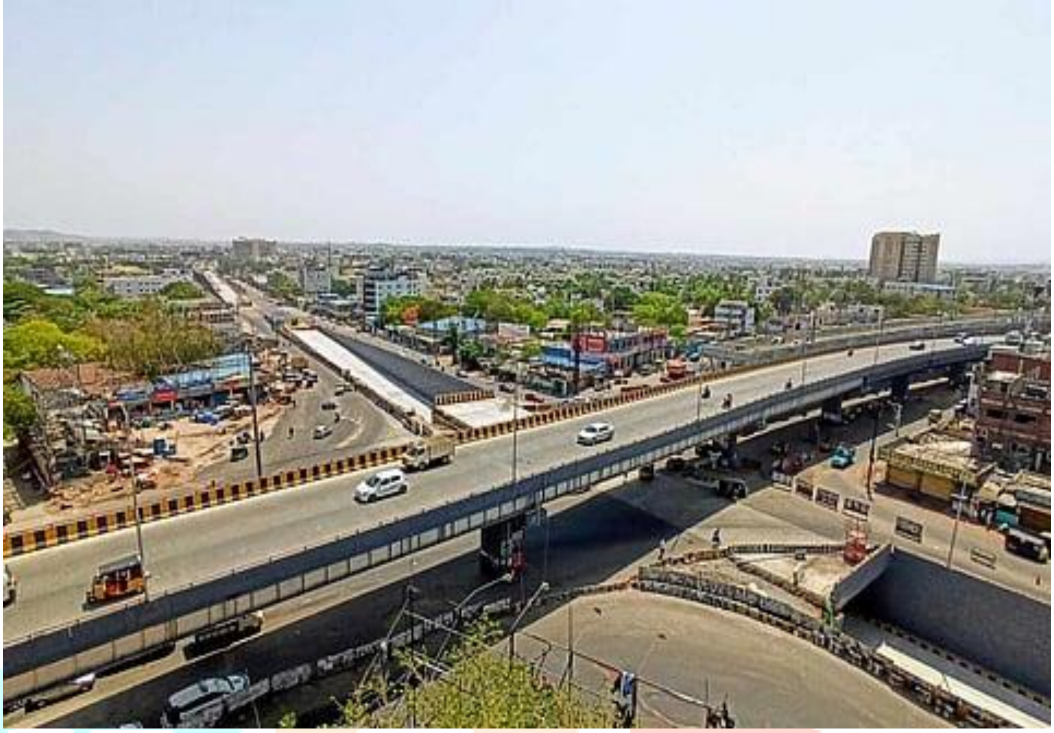
Figure 3.1: Flow chart of Methodology

IV. STUDY AREA

4.1 Climate of LB Nagar, Hyderabad

LB Nagar, Hyderabad has a tropical wet and dry climate bordering on a hot semi-arid climate. The annual mean temperature is 26.6 °C (79.9 °F); monthly mean temperatures are 21–33°C(70–91°F). Summers(March–June) are hot and dry, with average highs in the mid-to-high 30s Celsius. Maximum temperatures often exceed 40 °C (104 °F) between April and June. The coolest temperatures occur in December and January, when the lowest temperature occasionally dips to 10 °C (50 °F). May is the hottest month, when daily temperatures range from 26–39 °C (79–102 °F); December, the coldest, has temperatures varying from 14.5–28 °C (58.1–82.4 °F). Heavy rain from the south-west summer monsoon falls between June and October, supplying LB Nagar, Hyderabad with most of its mean annual rainfall. Since records began in November 1891, the heaviest rainfall recorded in a 24-hour period was 241.5 mm (10 in) on 24 August 2000. The highest temperature ever recorded was 45.5 °C (114 °F) on

2 June 1966, and the lowest was 6.1 °C (43 °F) on 8 January 1946. The city receives 2,731 hours of sunshine per year; maximum daily sunlight exposure occurs in February.



4.2 Flash floods in LB Nagar, Hyderabad on 13 October 2020

The 2020 Hyderabad floods were a series of floods associated with Deep Depression BOB 02 that caused extensive damage and loss of life as a result of flash flooding in LB Nagar, Hyderabad, India in October 2020. On 11 October, an area of low pressure concentrated into a depression over the west-central Bay of Bengal. It further intensified into a deep depression on 12 October as it moved slowly west- north-westwards. After that, BOB 02 made landfall in Andhra Pradesh near Kakinada in the early hours of 13 October and weakened again into a depression. The system weakened into a well- marked low-pressure area over south-central Maharashtra on the evening of 14 October. Though the system's low-level circulation was partially exposed due to high vertical wind shear and continuous land interaction, the JTWC re-issued a tropical cyclone advisory on 15 October. The IMD also forecasted BOB 02 to reintensify in the Arabian Sea. The low-pressure area intensified into Depression ARB 03 in the early hours of 17 October. The system delayed the withdrawal of southwest monsoon season by almost a week. The floodgates of the Himayat Sagar were lifted as the water reached full reservoir levels, and the Musi river flowed full stream, flooding several localities and flowing over two causeway bridges. Due to BOB 02, Puducherry, Andhra Pradesh, Telangana, Kerala, Maharashtra, and Coastal Karnataka experienced heavy rain on 12 and 13 October with the capital city, with LB Nagar, Hyderabad experiencing 32 cm of record breaking torrential rain creating flash floods on the city by 13 October 2 people died in Vijayawada, and 50 people died on different parts of Telangana, including 19 in LB Nagar, Hyderabad. Additionally, twenty seven people died in Maharashtra. Extreme crop loss in north Karnataka, Andhra Pradesh and Telangana occurred due to the system. The Chief Minister of Telangana estimated 5,000 crore (US$681 million) worth of damage. On 18 October, a second cyclone killed two more people in Hyderabad. Over 37,000 families were affected by the second flood. Rainfall reached over 110 millimetres (43 inch) in parts of LB Nagar, Hyderabad, with heavier rainfall amounts outside of the city. With over 80 people having lost their lives and about 40,000 families being displaced, post rain gathering up-to 20,000 tons of waste.

V. CALCULATION & OBSERVATION

5.1 Empirical Method

The Evaluating Discharge(Q) for Hyderabad with catchment area (A)=217 km² with various empirical formulae

5.1.1 Dickens Formula

$Q = C*A^{3/4}$

$= 15*(217)^{3/4}$ {C=15}

=848.07 cumecs

5.1.2 Ryve's Formula

$Q = C*A^{2/3}$

$= 8.5*(217)^{2/3}$ {C=8.5}

=306.94 cumecs

5.1.3 Inglis's Formula

$Q = 124 * A \div \sqrt{A + 10.4}$

$= 124*217 \div \sqrt{217 + 10.4}$

= 1784.37 cumecs

5.1.4 Ali Nawaz Jung Bahadur Formula

Q = C*(0.386*A)

= 5 *(0.386*217) {C=5}

=418.81 cumecs

5.1.5 Meyer's Formula

$Q=176*P*A^{1/2}$

$= 176*0.5*217^{1/2}$ {P=0.5}

= 250.37 cumecs

5.2 Design of Open Drainage System for LB Nagar

Area of LB Nagar (A) = 2.97 km^2 = 297 ha

5.2.1 Discharge (Q)
Q = CIA / 360
$Q = 80 * 120 * 2.97 * 10^6$
$Q = 80 * 10^6\ m^3$

5.2.2 Velocity of flow (V)
$V = (Q*F^2 / 140)^{1/6}$
$V = (80*10^6*1^2/140)^{1/6}$
V = 4.22 m/s

5.2.3 Discharge Area (A)
A = Discharge /Velocity
$A = 80 * 10^6 / 4.22$
$A = 189.57\ km^2$

5.2.4 Total Dimensions of Roads
Total Length of roads (l) = 119 km
Total Width of roads (b)
= Discharge Area / Total Length
= 189.57 /160
= 1.184 ~ 1.2
Take depth of roads (h) = 1m (h = 0.8-1)

5.2.5 Total width to carry the discharge
$Width (B) = 80*10^6 / 160*10^3$
= 500m

5.2.6 Number of drainages to be built
No. of drainages = 500 / 1.2
= 417 Nos

5.3 Estimation Cost of Open Drainage System

Sr. No	Particulars	NO.	Length (m)	Breadth (m)	Height (m)	Quantity	Rate/ m^3 in ₹	Amount in ₹
1	Earthwork in Excavation	100	1000	1.2	1	1200	25	3000000
2	P.C.C in Foundation (1:4:8)	100	1000	1.2	0.1	120	300	3600000
3	Brickwork in 1:6 cement sand mortar	200	1000	0.15	0.9	270	425	11475000
4	P.C.C (1:2:4) work	200	1000	0.9	0.15	270	50	202500
	Deduct: Semi circular portion	-	1000	$\frac{\pi * 0.15^2}{2}$ =0.035		35	-1.225	-4200 =198300
5	12mm thick cement plaster in circular portion(1:2)	100	1000	$\pi * 0.15$ =0.471	-	471	20	942000
6	12mm thick cement plaster in remaining portion (1:4)	200	1000	0.75+0.15+0.1 =1 m	-	2000	15	3000000
7	***LABOUR CHARGES***							
a	Man Mazdoor	15000	-	-	-	-	1200	18000000
b	Woman Mazdoor	15000	-	-	-	-	1000	15000000
c	Man Beldar	15000	-	-	-	-	1000	15000000
d	Woman Beldar	15000	-	-	-	-	850	12750000
8	Transportation Charges		-	-	-	-	-	7034700
9	Add 10% contingencies and work charge establishments							10000000
						Total	***₹10,00,00,000***	

∴ Cost required to construct 1 Km 'U' Shaped Open Drainage System=₹10,00,00,000/-

∴ Total Cost required to construct 160 Km 'U' Shaped Open Drainage System

=₹10,00,00,000*160 =₹1600,00,00,000l-

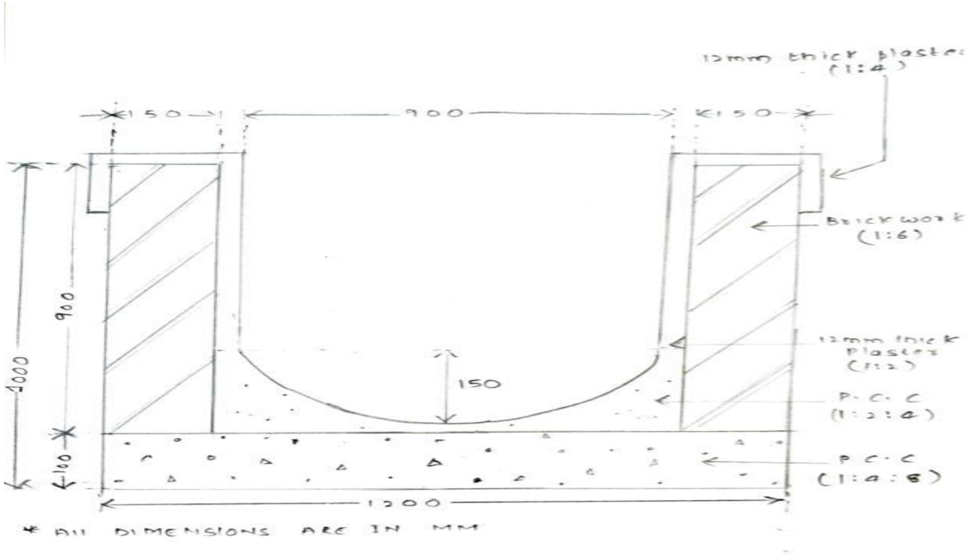


Fig. 'U' Shaped Drainage

VI CONCLUSION

In this project, we have conducted a detailed observation and analysis of rainfall patterns in urban areas, with a special focus on the area of LB Nagar which is in the South Eastern parts of Hyderabad City. Urban areas are increasingly vulnerable to the adverse effects of heavy rainfall due to rapid urbanization, inadequate drainage infrastructure, and limited natural water absorption zones. Our primary objective was to understand how rainfall behaves in such settings and to design an efficient open drainage system that could help manage rainwater effectively, preventing water-logging and urban flooding.

The study began with a thorough literature review of existing data, research, and drainage systems both in India and internationally. We then moved on to the measurement and analysis of rainfall data collected from multiple reliable sources, including meteorological departments and local weather stations. Special attention was paid to high-intensity and short-duration rainfall events, which are often responsible for flash flooding in cities like Hyderabad.

Next, we conducted field visits and site inspections across various roads and lanes of Hyderabad. These visits helped us observe ground realities such as poor slope design, clogged or absent drains, and encroachments on natural water paths. We also identified areas that are most frequently affected by water-logging during monsoon seasons.

Our study included the measurement of runoff from different surfaces, such as asphalt roads, concrete pavements, and open grounds. Based on this, we were able to estimate the volume of water that needs to be effectively drained during peak rainfall conditions. These measurements were crucial in helping us estimate the flood discharge in various zones of the city.

With all the data collected, we designed an Open Drainage System that takes into account the topography, rainfall intensity, existing infrastructure, and projected urban growth of Hyderabad. The design ensures that storm water is quickly and efficiently carried away from roads and residential areas into designated discharge points such as natural streams, lakes, or larger municipal storm water drains. We also considered the possibility of recharging groundwater by incorporating features like percolation pits and rainwater harvesting trenches in suitable locations.

During our research, we also studied the impacts of urban flooding, which include damage to property and infrastructure, traffic disruptions, water contamination, and health hazards due to stagnant water. We found that the most vulnerable groups, including low-income communities living in poorly planned neighbourhoods, are often the worst affected. These findings further emphasized the need for a well-planned and implemented drainage system.

Our proposed design not only addresses the current challenges but is also scalable and adaptable for future needs. It incorporates sustainable and eco-friendly solutions wherever possible, ensuring minimal environmental impact while maximizing efficiency. The implementation of such a system can greatly reduce the risk of urban flooding, improve road safety, and enhance the overall resilience of Hyderabad to climate change and unpredictable weather patterns.

In conclusion, this project highlights the critical importance of understanding rainfall behaviour and managing urban water flow through scientifically designed drainage systems. The drainage solution we have developed is expected to be highly beneficial for Hyderabad, especially in light of increasing rainfall intensities and frequent flood events. If properly implemented and maintained, this design can help prevent many of the adverse impacts caused by floods and contribute to building a safer, more sustainable urban environment for the city's residents.

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